

SPECIFICATION

PACKAGE FOR OPTICAL SEMICONDUCTOR DEVICE

5 BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to packages for Optical semiconductor devices, especially a package for Optical semiconductor devices excellent in high frequency
10 characteristics.

2. Description of the Background Art

In recent years, the transmission rate is accelerated one after another from 600Mbps to 2.5Gbps, moreover to 10Gbps, in the field of optical communications. Therefore,
15 the light emitting devices and the photo detectors for optical transmitter-receivers are required for quick-operating. With this, good high frequency characteristics and low cost are required for the packages of the light emitting devices and the photo detectors. There are a stem
20 type package in coaxial form having a simple structure and a butterfly type package using a strip line in box form for the light emitting devices and the photo detectors.

The conventional stem type package is constituted as follows by using the stem-body 113, as shown in Fig. 9A and
25 Fig. 9B. Pair of lead terminals 105 for photodiodes and a

lead terminal 112 for signal supply are inserted in the through holes of stem-body 113 respectively so as to be insulated by a glass 106. Moreover, a sub-mount 102 and a mount 901 in which a semiconductor laser 103 is mounted are arranged adjoins the lead terminal 112 for signal supply on the upper surface of the stem-body 113, and a recess 109 in which sub-mount 108 and the photodiode 107 for monitor are attached formed at the upper surface of stem-body 113. Here, the recess 109 is formed in a position where the laser light from the monitor side edge face opposite to light emitting edge face of the semiconductor laser diode is inputted into the photodiode 107 for monitors mounted on sub-mount 108. In addition, an earth lead terminal is attached and shown with the code of 114 in Fig. 9A.

A semiconductor laser 103 is mounted on one side of mount 901 with sub-mount 102 between them, the photodiode 107 for monitor is mounted on the recess 109 with sub-mount 108 between them and then the predetermined lead terminals are connected with a wire 104, 110, 111. Thereby, a semiconductor laser device having the stem formed as mentioned above is constituted (for example, U.S.P. non examined publication No. 2002/0041612A1, and 2002/0141142A1).

In the semiconductor laser device formed as mentioned above, when a voltage of about 1.5V is applied between the

lead terminal for signal supply 112 and the earth lead terminal 114, an electrical current of tens mA is flowed in the semiconductor laser device and a laser light is emitted. And a light emitted from the edge face opposite to the light emitting face is received at the monitor photodiode 107 to control the quantity of the emitted light.

In the stem type packages for optical semiconductor device, the structures with good heat radiating properties capable of radiating the heat generated by the semiconductor laser devices are shown in the documents of Japanese Non-examined Patent Publications No.58-98995, No.07-240565 and U.S.Patent No.5,262,675.

However, in the conventional package for Optical semiconductor device, although the high frequency characteristics of a butterfly type package are good, it is very expensive by the complicated structure. On the other hand, although the stem type package is cheap, high frequency characteristics are not good, so it is difficult to be used for high-speed transmission of 10Gbps or more.

SUMMARY OF THE INVENTION

Therefore, an object of the invention is to provide a stem type package with good high frequency characteristics, which can be used for high-speed transmission of 10Gbps or more.

The package for Optical semiconductor devices of the invention includes a stem which has an under surface, an upper surface and one or more through holes penetrating from the upper surface to the under surface, a mount to be
5 mounted with an optical semiconductor device on the upper surface, a lead terminal for signal supply penetrating one of the through holes so as to be insulated by an insulator. And in order to attain the object, the package of the present invention is characterized in that the upper
10 surface has an earth conductor adjacent to the lead terminal for signal supply projected from the upper surface so that a difference between the characteristic impedance of the transmission line constituted with the through hole, the insulator and the lead terminal for signal supply and
15 the characteristic impedance of the transmission line constituted with a lead terminal for signal supply projected from the upper surface becomes small.

According to the present invention, the stem type packages for Optical semiconductor devices having good high
20 frequency characteristics, which can be used for high-speed transmission of 10Gbps or more, can be obtained.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1A is a perspective view of the optical
25 semiconductor device of Embodiment 1 of the present

invention.

Fig. 1B is a plan view of the optical semiconductor device of Embodiment 1 of the present invention.

5 Fig. 2A is a graph showing the analyzing results of the impedance (characteristic impedance) of the transmission line D with respect to the surrounding angle θ by a three dimensional electromagnetic field simulator.

Fig. 2B is a graph showing the simulation results of the dependence of the reflection coefficient S11 (dB) on
10 angle θ on the border between the transmission line C and the transmission line D.

Fig. 3A is a perspective view of the optical semiconductor device of Embodiment 2 of the present invention.

15 Fig. 3B is a plan view of the optical semiconductor device of Embodiment 2 of the present invention.

Fig. 4A is a perspective view of the optical semiconductor device of Embodiment 3 of the present invention.

20 Fig. 4B is a plan view of the optical semiconductor device of Embodiment 3 of the present invention.

Fig. 5A is a perspective view of the rear side of the optical semiconductor device of Embodiment 4 of the present invention, when connected with the feeding substrate.

25 Fig. 5B is a plan view of the rear side of the optical

semiconductor device of Embodiment 4 of the present invention, when connected with the feeding substrate.

Fig. 6 is a graph showing the analyzing results of the electric reflection coefficient S_{11} (dB) in the connection part B by a three-dimensional electromagnetic simulator.

Fig. 7A is a perspective view of the rear side of the optical semiconductor device of a variation example of Embodiment 4, when connected with the feeding substrate.

Fig. 7B is a plan view of the rear side of the optical semiconductor device of a variation example of Embodiment 4, when connected with the feeding substrate.

Fig. 8A is a perspective view of the optical semiconductor device of Embodiment 5 of the present invention.

Fig. 8B is a plan view of the optical semiconductor device of Embodiment 5 of the present invention.

Fig. 9A is a perspective view of the conventional optical semiconductor device.

Fig. 9B is a plan view of the conventional optical semiconductor device.

Fig. 10A is a perspective view of the rear side of the optical semiconductor device, when connected with the feeding substrate.

Fig. 10B is a plan view of the rear side of the optical semiconductor device, when connected with the

feeding substrate.

Fig. 11A is a perspective view of the optical semiconductor device of Embodiment 6 of the present invention.

5 Fig. 11B is a plan view of the optical semiconductor device of Embodiment 6 of the present invention.

Fig. 12 is a cross sectional view taken along the line A-B of Fig. 11B.

10 Fig. 13 is a graph showing the calculation results of the characteristic impedance when in the package for the optical semiconductor device of Embodiment 6, the spacing W between the lead terminal for signal supply 112 and a circumference face 61a is changed.

15 Fig. 14 is a graph showing the reflection S11 and the transmission characteristics S21 from the input terminal of the lead terminal for signal supply to the input terminal of the semiconductor laser in the optical semiconductor device of Embodiment 6.

20 Fig. 15 is a partial cross sectional view of the lead terminal for signal supply 112 and its periphery in the optical semiconductor device of Embodiment 7.

Fig. 16A is a perspective view of the optical semiconductor device of Embodiment 8 of the present invention.

25 Fig. 16B is a plan view of the optical semiconductor

device of Embodiment 8 of the present invention.

Fig. 17 is a cross sectional view taken along the line A-B of Fig. 16B.

Fig. 18 is a partial cross sectional view of the lead
5 terminal for signal supply 112 and its periphery in the optical semiconductor device of Embodiment 9.

Fig. 19A is a partial cross sectional view of the lead terminal for signal supply 112 and its periphery in the optical semiconductor device of Embodiment 10.

10 Fig. 19B is a partial cross sectional view of the lead terminal for signal supply 112 and its periphery in the optical semiconductor device of Embodiment 11.

Fig. 20 is a partial cross sectional view of the lead terminal for signal supply 112 and its periphery in the
15 optical semiconductor device of Embodiment 12.

Fig. 21A is a perspective view of the optical semiconductor device of a variation example of the present invention.

Fig. 21B is a plan view of the optical semiconductor
20 device of a variation example of the present invention.

Fig. 22A is a perspective view of the optical semiconductor device of the comparative example.

Fig. 22B is a plan view of the optical semiconductor device of the comparative example.

25 Fig. 23 is a cross sectional view taken along the line

A-B of Fig. 22B.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Hereafter, the optical semiconductor device of the
5 embodiment according to the invention is explained,
referring to the drawings.

Embodiment 1.

Figure 1A and 1B are a perspective diagram and plane
view of the optical semiconductor device of Embodiment 1
10 concerning this invention.

The optical semiconductor device of this embodiment 1
is a laser device for optical communications, and is
constituted using a package for Optical semiconductor
device peculiar to the present invention and Optical
15 semiconductor element such as a laser diode.

In the optical semiconductor device of this embodiment
1, the package for Optical semiconductor device is similar
to the conventional package for Optical semiconductor
device in Fig. 9 except that a mount 101 is used instead of
20 the mount 901 in order to make high frequency
characteristics good. In addition, in Fig. 1, the same
elements as Fig. 9 are attached with the same code.

In the optical semiconductor device of an embodiment 1,
the mount 101 of the package for Optical semiconductor
25 devices has a mount face 101b to be mounted by a laser

diode 103 and a circumference face 101a which encloses the lead terminal 112 for signal supply as shown in Fig. 1A and 1B. For example, the mount 101 is made of a metal excellent in electrical conductivity and thermal conductivity.

A sub-mount 102 is mounted on the mount face 101b and the laser diode 103 is mounted on the sub-mount 102. The mount 101 attached with the sub-mount 102 and the laser diode 103 is arranged on the upper surface of a stem-body 113 so that the attached laser diode 103 is located in the upper part simultaneously central part of the stem-body 113 and the axis of the circumference face 101a coincide with the axis of the lead terminal 112 for signal supply. The diameter of the circumference face 101a of the mount 101 is set so as to be almost same as that of the through hole in which the lead terminal 112 for signal supply is inserted in the package for Optical semiconductor device here. The mount 101 is made of metal such as iron, an iron alloy, copper and a copper alloy, or a metallized dielectric material and the earth conductor surrounding the lead terminal 112 for signal supply is constituted by the circumference face 101a of the mount 101 in the Optical semiconductor device of embodiment 1.

In addition, the size of each element in the package for Optical semiconductor devices of this embodiment 1 is

set within a following range.

Diameter of the stem-body 113: 2-10mm,

Thickness of the stem-body 113: 0.5-2mm,

5 Height of the lead terminal 112 for signal supply
projected from the upper surface of the stem-body 113:
0.3mm - 2mm,

Height of the mount 101: 0.3mm - 2mm,

Diameter of the glass part 106 (through hole pore
size): 0.3mm - 3mm,

10 Diameter of the lead terminal 112 for signal supply:
0.2mm - 2mm,

In the optical semiconductor device of embodiment 1
constituted as mentioned above, the signal supplied to the
lead terminal 112 for signal supply is transmitted by a
15 transmission line C and a transmission line D and is
supplied to the semiconductor laser diode 103. The
transmission line C is a portion constituted with an inner
wall of the through hole and the glass part 106, and the
lead terminal 112 for signal supply, and the transmission
20 line D is a portion constituted with the lead terminal 112
for signal supply which were projected from the upper
surface of the stem-body 113 and the circumference face
101a.

Since the transmission line D is constituted from the
25 lead terminal 112 for signal supply projected from the

upper surface of the stem-body 113 surrounded by the circumference face 101a in the package for the optical semiconductor device in this embodiment 1, the impedance of the transmission line D can be made low. Thereby, the impedance mismatching between a transmission line C and a transmission line D can be made small. With this, even if the high frequency signal of 10Gbps or more is supplied to the semiconductor laser diode, the reflection at the boundary of the transmission line C and the transmission line D can be suppressed, so the high frequency transmission characteristic can be made good. Moreover, in this embodiment 1, when the mount 101 is made monolithically with the stem-body 113, the manufacturing will be easy.

Hereafter, the reflective characteristics between transmission lines is explained in detail contrasting with the conventional example.

Generally, an electric supply to an optical semiconductor device is carried out by using an electric supply substrate. For example, a high frequency signal is supplied to the optical semiconductor device, such as a laser diode, through a transmission line A, the connection portion B, a transmission line C, and a transmission line D as shown in Fig. 10. Here, the transmission line A, which is a transmission line on an electric supply substrate 117,

consists of a signal line 115 and ground lines 116 formed in parallel with the signal line on the substrate 117. The signal line 115 is connected to the lead terminal 112 for signal supply and the ground lines 116 is connected to the earth lead terminal 114.

Moreover, the connection portion B, which is a connection portion between the transmission line A and the transmission line C, generates a mismatching of impedance.

Furthermore, the transmission line C is constituted by the through hole of the stem-body 113. That is to say, the transmission line C is constituted of the inner wall of the through hole, the glass part 106 and the lead terminal 112 for signal supply.

Moreover, the transmission line D is constituted with the lead terminal 112 for signal supply projected from the upper surface of the stem-body 113.

In order to supply an inputted high frequency signal to the semiconductor laser without reflecting at the connection portions of the transmission lines, it is preferable that the characteristic impedances of the transmission-lines A-D are almost same each other.

However, each impedances of the transmission-lines A-D is determined by the physical form of the element which constitutes each transmission line and it is necessary to determine the physical form of the transmission-line

considering the form of the optical semiconductor-device, mechanical hardness, etc. Therefore, the physical form of the transmission-line cannot be determined freely.

When the diameter of the lead terminal 112 for signal supply is set in a range of 0.35mm - 0.45mm, the diameter of the through hole of the stem is set in a range of 0.7-1mm and the interval between the center of the lead terminal 112 for signal supply the center of the earth lead terminal 114 is set in a range of 1mm - 2mm, the impedance of each transmission line is as follows

That is, if the interval between the center of the lead terminal 112 for signal supply the center of the earth lead terminal 114 is set in a range of 1mm - 2mm, the impedance Z_b of a transmission line B, which is determined by the interval between the centers of the lead terminal 112 and the earth lead terminal 114, is set to about 160ohms.

The impedance Z_c of the transmission line C which is determined by the diameter (diameter of glass material) of the through hole and the diameter of the lead terminal 112 for signal supply is set to about 20ohms.

In the structure of the conventional example of Fig. 9, the impedance Z_d of the transmission line D, which is determined by the diameter of the lead terminal 112 for signal supply and the relation with other elements, is in

about 70 ohms.

If the impedance Z_a of the signal line 115 is 25 ohms, since the impedance of the connection portion B and the impedance of the transmission line D are higher than the
5 signal line 115, a large reflection will arise at the boundary between the transmission lines.

For example, although -10dB or less is required for the reflection coefficient S_{11} at 10GHz in order to modulate with the transmission rate of 10Gbps, the
10 reflection of -5dB or more arises in the composition of the conventional figure 9 and good characteristics can not be obtained.

On the other hand, the reflection between the transmission line C and the transmission line D can be made
15 small in the optical semiconductor device of this embodiment 1. The simulated impedance (characteristic impedance) of the transmission line with respect to the enclosure angle θ by the 3-dimensional electromagnetic-field simulator is shown in Fig. 2A. The simulated
20 reflection coefficient S_{11} (dB) at the boundary between the transmission line C and the transmission line D depending on the angle θ is shown in Fig. 2B. In Fig. 2A, 2B, the result (dashed line); which is simulated at 10 GHz on the case where the diameter of the lead terminal 112 for signal
25 supply is set to 0.45mm and the inside diameter of the

enclosure section is set to 1mm, the result; which is simulated at 10 GHz on the case where the diameter of the lead terminal 112 for signal supply is set to 0.35mm and the inside diameter of the enclosure section is set to 0.7mm, are shown. The impedances tend to lower as the enclosure angle θ becomes large, as shown in Fig. 2A.

Moreover, the reflection coefficient S11 (dB) at the boundary between the transmission line C and the transmission line D is decreased as the enclosure angle θ becomes large, as shown in Fig. 2B.

In addition, it is preferable that the enclosure angle θ is 150 degrees or more so that the reflection coefficient S11(dB) is -10dB or less as shown in Fig. 2B. Moreover, since there is also reflection in other portions except for the boundary between the transmission line C and the transmission line D, it is preferable that the reflection coefficient S11 (dB) at the boundary between the transmission line C and the transmission line D is -12dB or less and the enclosure angle theta for realizing the reflection of -12dB or less is 210 degrees or more.

Thus, in a transmission line D, when the earth conductor is formed to surround at least part of the lead terminals for signal supply, that the earth conductor preferably should be formed so as to surround the lead terminal 112 for signal supply preferably in a range of 150

degrees or more centering on the axis of the lead terminal 112, more preferably in a range of 210 degree or more in order to lower the characteristic impedance of the transmission line D effectively.

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Embodiment 2

The optical semiconductor device of Embodiment 2 of the present invention is composed using a package for optical semiconductor device with improved high frequency properties as will be described below. To be more specific, as shown in Fig. 3 the package for optical semiconductor device of Embodiment 2 has the same structure as the conventional package for optical semiconductor device shown in Fig. 9 except that in the conventional package the counter earth electrode part 201 made of a conductive member, a dielectric member having a metalized surface or the like is further provided adjacent to the lead terminal for signal supply 112:

In Embodiment 2, the lead terminal for signal supply 112 and the counter earth electrode part 201 compose the transmission line D, which has lower impedance than in the conventional example shown in Fig. 9.

The result is a reduction in reflection coefficient between the transmission line C and the transmission line D.

As described hereinbefore, the optical semiconductor

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devices of Embodiments 1 and 2 are composed using the
aforementioned package for optical semiconductor device
unique to the present invention, which makes them optical
semiconductor devices excellent in high frequency
5 properties.

To be more specific, the package for optical
semiconductor device in the optical semiconductor devices
of Embodiments 1 and 2 is provided with an earth conductor
(the mount 101 in the vicinity of the circumference face
10 101a, the counter earth electrode part 201) adjacent to the
lead terminal for signal supply projected from the upper
surface of the stem body 113 so that the difference in
characteristic impedance can be small between the
transmission line C which is composed of a through hole
15 perforated in the stem body 113 and the lead terminal for
signal supply inserted into the through hole via glass
material (in such a manner as to be insulated from the stem
body) and the transmission line D which is composed of the
lead terminal for signal supply 112 projected from the
20 upper surface.

This can provide an optical semiconductor device
excellent in high frequency properties.

Embodiment 3

25 The optical semiconductor device of Embodiment 3 of

the present invention is composed using a package for optical semiconductor device with improved high frequency properties as will be described below. To be more specific, as shown in Fig. 4 the package for optical semiconductor device of Embodiment 3 has the same structure as the package for optical semiconductor device of Embodiment 2 except that in the package of Embodiment 2 a dielectric plate 301 (for example, a dielectric member having a relative permittivity of 2 to 12, more specifically made of alumina or the like) is further provided between the counter earth electrode part 201 and the lead terminal for signal supply 112.

In Embodiment 3, the lead terminal for signal supply 112, the counter earth electrode part 201, and the dielectric plate 301 compose the transmission line D. The relative permittivity of this dielectric plate which is higher than in a vacuum (in the air) enables the transmission line D to have lower impedance than in the package for optical semiconductor device of Embodiment 2 shown in Fig. 3.

The result is a reduction in the difference in characteristic impedance between the transmission line C and the transmission line D.

Although Embodiment 3 provides the dielectric plate 301 between the counter earth electrode part 201 and the

lead terminal for signal supply 112 in Embodiment 2, the present invention is not restricted to this structure; in Embodiment 1, it is possible to provide a dielectric member between the circumference face 101a of the mount 101 and the lead terminal for signal supply 112, which can further reduce the difference in characteristic impedance between the transmission line C and the transmission line D in Embodiment 1.

10 Embodiment 4

The optical semiconductor device of Embodiment 4 of the present invention is composed using a package for optical semiconductor device with improved high frequency properties as will be described below. To be more specific, as shown in Fig. 5 the package for optical semiconductor device of Embodiment 4 has the same structure as the conventional package for optical semiconductor device except that in the conventional package the lead terminal for ground 414 is further provided.

20 In the package for optical semiconductor device of Embodiment 4, the lead terminal for ground 414 is arranged in such a manner that it sandwiches the lead terminal for signal supply 112 with the lead terminal for ground 114.

The package for optical semiconductor device of Embodiment 4 thus structured can reduce reflection in the

connection part B.

Fig. 6 is a graph showing the analyzing results of the electricity reflection coefficient S_{11} (dB) in the connection part B with respect to the spacing W (μm) between the stem body 113 and the feeding substrate 117 by a three dimensional electromagnetic field simulator. In this simulation, the spacing between the center axes of the lead terminal for ground 414 and the lead terminal for signal supply 112, and the spacing between the center axes of the lead terminal for ground 114 and the lead terminal for signal supply 112 were set to 1 mm. The spacing between the center axes of the lead terminal for ground 114 and the lead terminal for signal supply 112 in the conventional example was also set to 1 mm.

Fig. 6 indicates that the optical semiconductor device of Embodiment 4 having the lead terminal for signal supply 112 between the lead terminal for ground 414 and the lead terminal for ground 114 can reduce the reflection coefficient S_{11} if the spacing W is the same. The effect of reflection coefficient reduction becomes conspicuous when the spacing between the stem body 113 and the feeding substrate is continuously reduced, compared with the conventional example.

In the optical semiconductor device of Embodiment 4 described hereinbefore, the reflection coefficient can be

not more than -10dB even when the spacing between the stem body 113 and the feeding substrate becomes 500 μ m or so, which is required in the case of normal mounting method.

On the other hand, in the conventional structure of Fig. 9, the reflection coefficient becomes -5dB when the spacing between the stem body 113 and the feeding substrate is about 500 μ m.

In the aforementioned optical semiconductor device of Embodiment 4, as shown in Fig. 7 the lead terminal for ground 414 and the lead terminal for ground 114 can be replaced by metal protrusions monolithically integrated with the stem body 113.

Embodiment 5

The optical semiconductor device of Embodiment 5 of the present invention, as shown in Fig. 8, is an optical semiconductor device of differential feeding system having two lead terminals for signal supply 112. In each of the lead terminals for signal supply 112 projected from the upper surface of the stem body 113, the same transmission line D as in Embodiment 1 is formed by being surrounded by the metallic circumference face.

The optical semiconductor device of Embodiment 5 has the same structure as that of Embodiment 4 where in the rear side of the stem body 113, each of the lead terminals

for signal supply 112 is sandwiched between the lead terminals for ground 414 and the lead terminal for ground 114.

The optical semiconductor device of Embodiment 5 thus structured has both the effects of Embodiments 1 and 4, which can suppress signal reflection effectively.

As described hereinbefore, the optical semiconductor devices of Embodiments 1 to 5 of the present invention are composed using a package for optical semiconductor device which can reduce signal reflection between the transmission lines A to D, thereby providing optical semiconductor devices with excellent high frequency properties.

These embodiments describe examples having a laser device as the optical semiconductor device. However, the present invention is not restricted to this; a photoreceptor device can be used as the optical semiconductor device to obtain the same effects as those of the embodiments.

The embodiments described below show preferred embodiments when manufacturability is taken into consideration in the specific structure of the present invention.

The optical semiconductor device of Embodiment 1 shows that the characteristic impedance can be 50Ω or so by setting the surrounding angle of the lead to not less than

200 degrees.

In the stem-type package for optical semiconductor device, when it is composed of a metal conductor such as iron, the stem body 113 and the mount 101 are integrally
5 subjected to press-processing by taking mass production properties into consideration.

However, if it is tried to form the stem-type package for optical semiconductor device of Embodiment 1 equipped with the mount 101 including the circumference face 101a
10 shown in Fig. 1 by monolithically integrating the stem body 113 and the mount 101 by press-processing, it becomes difficult to form a mount having a sufficient surrounding angle, and it is also impossible to sufficiently lower the impedance because the edge is rounded off.

15 To be more specific, as shown in Figs. 22A and 22B, it is impossible to sufficiently reduce the characteristic impedance partly because the following reasons:

(1) the mount 601 to be obtained has a small surrounding angle (about 100 degrees), and a round edge
20 (shown with the reference number 601c); and

(2) if it is tried to monolithically integrate the stem body 113 and the mount 601 by press-processing, as shown in Fig. 23 the circumference face 601a of the mount 601 must be apart from the glass part 106 (the outer
25 surface of the through hole) by a distance S (about $100\mu\text{m}$),

making it impossible to make the circumference face 601a and the lead terminal for signal supply 112 close to each other.

If production constraints are taken into consideration,
5 high frequency properties good enough cannot be obtained.

Therefore, Embodiments 6 to 12 provide specific
embodiments of a package for optical semiconductor device
capable of reducing the characteristic impedance small
enough while taking the production constraints into
10 consideration.

Embodiment 6

Fig. 11A is a perspective view of the optical
semiconductor device of Embodiment 6, and Fig. 11B is the
15 top view thereof. Fig. 12 is a cross sectional view taken
along the line A-B of Fig. 11B.

In the package for optical semiconductor device of
Embodiment 6, a mount 61 is provided in such a manner as to
cover part of the outer surface part of the glass material
20 106 in an attempt (1) to subject the mount 61 and the stem
body 113 to press-processing separately; and (2) to reduce
the distance between the circumference face 61a of the
mount 61 and the lead terminal for signal supply 112.

Thus, in the package for optical semiconductor device
25 used in the optical semiconductor device of Embodiment 6,

the mount 61 having the circumference face 61a with a diameter smaller than the glass material 106 and larger than the lead terminal for signal supply 112 is first produced separately from the stem body 113 by press processing.

Then, on the stem body 113 provided with the lead terminal for signal supply 112 in the through hole via the glass material 106 is arranged the mount 61 in such a manner that the lead terminal for signal supply 112 and the circumference face 61a become coaxial.

To be more specific, in Embodiment 6, the radius R_{glass} of the glass material 106, the radius R_{lead} of the lead terminal for signal supply 112, and the radius R_{cff} of the circumference face 61a are set so as to satisfy the relation of $R_{\text{glass}} > R_{\text{cff}} > R_{\text{lead}}$, so that the distance W between the outer circumference of the lead terminal for signal supply 112 and the circumference face 61a can be the difference between the radius R_{cff} of the circumference face 61a and the radius R_{lead} of the lead terminal for signal supply 112 ($W = R_{\text{cff}} - R_{\text{lead}}$).

It goes without saying that $W < R_{\text{glass}} - R_{\text{lead}}$.

Fig. 13 shows the calculation results of the characteristic impedance when the distance W or the radius R_{cff} of the circumference face 61a is changed by setting the radius R_{glass} of the glass material 106 to 0.35 mm, the

radius R_{lead} of the lead terminal for signal supply 112 to 0.175 mm, and the lead surrounding angle θ to 130 degrees.

In Fig. 13, in the case of $W = 0.175$ mm ($R_{cfl} - R_{lead}$), the outer circumference of the glass material and the circumference face 61a of the mount 61 agree with each other, and the characteristic impedance at that time is 60Ω .

In the case of $W < 0.175$ mm, the radius R_{cfl} of the circumference face 61a of the mount 61 becomes smaller than the radius R_{glass} of the outer circumference of the glass material, and the characteristic impedance becomes 60Ω or less. Assuming $W = 0.1$ mm, the characteristic impedance can be lowered down to 50Ω .

The reason for a decrease in the characteristic impedance of the lead part with reducing the distance W is that when the distance W is decreased, the electromagnetic field at the time of transmission of the lead terminal for signal supply 112 by a high frequency signal is confined more firmly between the circumference face 61a and the lead terminal for signal supply 112.

Fig. 14 is a graph showing the high frequency characteristics in the case of $W = 0.1$ mm, showing the reflection S_{11} and the transmission characteristics S_{21} from the input terminal of the lead terminal for signal supply 112 to the input terminal of the semiconductor laser

103. Fig. 14 shows, in addition to the high frequency characteristics of Embodiment 6, as a comparative example, the reflection S11 and the transmission characteristics S21 from the input terminal of the lead terminal for signal supply 112 to the input terminal of the semiconductor laser 103 in the package for optical semiconductor device (surrounding angle $\theta = 100$ degrees; the distance between the lead terminal for signal supply 112 and the circumference face = 0.275 mm) structured as shown in Figs. 22A and 22B.

Thus, in the stem-type package for optical semiconductor device of Embodiment 6, as compared with the package for optical semiconductor device used for comparison, the reflection S11 in 10 GHz was reduced by about 1 dB, and the transmission characteristics S21 and the electric transmission characteristics S21 were improved by 1 dB. This is because the characteristic impedance was able to be reduced down to 50Ω .

The package for optical semiconductor device of Embodiment 6 thus structured having a comparatively small surrounding angle (130 degrees with respect to 200 degrees or larger indicated as the preferable range in Embodiment 1) can be produced by the press processing excellent in mass production properties and be excellent in high frequency characteristics because the projecting part of

the lead terminal for signal supply can have low characteristic impedance by reducing the distance W.

Embodiment 7

5 Fig. 15 is a partial cross sectional view of the lead terminal for signal supply 112 and its periphery in the optical semiconductor device of Embodiment 7.

 The optical semiconductor device of Embodiment 7 is characterized by the provision of the guide 113a for
10 positioning the mount 101 in the stem body 113, and is designed so that the distance W between the lead terminal for signal supply 112 and the mount 101 can be set to a predetermined value in high precision (reproducibility has been improved).

15 Thus, in Embodiment 6, as has been explained with reference to Fig. 13, the impedance in the lead part is set depending on the value of the distance W; a change in the value of the distance W causes the value of the impedance to change (results in production variations).

20 In contrast, in the package for optical semiconductor device of Embodiment 7, the guide 113a can be formed in the stem body (monolithically integrated with the stem body, for example) to position the distance W between the lead terminal for signal supply 112 and the mount 61 in high
25 precision, thereby reducing variations in the impedance of

the lead part.

In the optical semiconductor device of Embodiment 7 thus structured, necessary precision in installing position can be secured when the mount 101 is installed on the stem
5 body 113 after the stem body 113 and the mount 101 are produced separately.

Embodiment 8

Fig. 16A is a perspective view of the optical
10 semiconductor device of Embodiment 8, and Fig. 16B is the top view thereof. Fig. 17 is a cross sectional view taken along the line A-B shown in Fig. 16B.

The optical semiconductor device of Embodiment 8 has the same structure as that of Embodiment 6 except that in
15 the optical semiconductor device of Embodiment 6, the lead terminal for signal supply 112 is replaced by the lead terminal for signal supply 212 having a tip portion crushed flat (preferably all part projected from the stem body 113) in an attempt to increase the surface area.

20 In the package for optical semiconductor device of Embodiment 8, the tip portion of the lead terminal for signal supply 112 is crushed flat to increase the surface area of the portion (flat part 212), so that the surface resistance in high frequency can be reduced, lowering the
25 characteristic impedance as the transmission line.

Also in the package for optical semiconductor device of Embodiment 8, the surface area of the flat part 212 of the tip portion is increased to enlarge the counter area against the circumference face 101a, which allows the
5 electromagnetic field to be confined more firmly between the lead terminal for signal supply 212 and the circumference face, thereby reducing the characteristic impedance.

10 Embodiment 9

As shown in Fig. 18 the optical semiconductor device of Embodiment 9 has the same structure as that of Embodiment 8 except that in the optical semiconductor device of Embodiment 8 the mount 101 is replaced by a mount
15 201m which has a counter surface crooked along with the lead terminal for signal supply 112.

When the lead terminal for signal supply 112 is cylindrical except for the flat part 212, the portion of the mount 201m that faces the lead terminal for signal
20 supply 112 is preferably structured as follows.

Of the part of the lead terminal for signal supply 112 that is projected from the stem body 113, the surface facing the cylindrical part is made the circumference face 201b so as to closely face the outer surface (circumference
25 face) of the lead terminal for signal supply 112 in the

fixed spacing.

The surface facing the flat part 212 of the lead terminal for signal supply 112 is made the flat surface 201a so that it can closely face the flat part 212 in the fixed spacing.

In Embodiment 9, the electromagnetic field can be more firmly confined than in Embodiment 8 between the flat part 212 of the lead terminal for signal supply 112 and the flat surface 201a and also between the lead terminal for signal supply 112 and the circumference face 201b, which can further reduce the characteristic impedance of the part of the lead terminal for signal supply 112 that is projected from the stem body 113.

Embodiment 10

As shown in Fig. 19A, the optical semiconductor device of Embodiment 10 is provided with a step (concave portion) S301 in the inner edge part of the mount 301 that faces the glass material 106 so that the mount 301 can be out of contact with the glass material 106.

The optical semiconductor device of Embodiment 10 thus structured can prevent the contact between the glass material 106 and the mount 301.

To be more specific, the glass material 106 incorporated into the stem body 113 may be projected from

the upper surface of the stem body as shown in Fig. 19A depending on the production method; in such a case, the contact between the glass material 106 and the mount 301 can be prevented.

5 Furthermore, when the stem body 113 and the mount 301 are joined to each other with solder or another material, the soldering material is prevented from adhering onto the glass material 106.

10 In the optical semiconductor device of Embodiment 10 thus structured, the mount 301 and the glass material 106 can be arranged apart from each other to prevent fluctuation in the characteristic impedance resulting from an unstable contact condition between the mount and the glass material 106.

15

Embodiment 11

As shown in Fig. 19B, the optical semiconductor device of Embodiment 11 is provided with the plinth 113b (convex part) on which to fix the mount 101 in the stem body 113.

20 In Embodiment 11, the mount 101 is installed on the plinth 113b in such a manner that the circumference face 101a is projected on the lead terminal for signal supply side from the plinth 113b (convex part).

25 In the optical semiconductor device of Embodiment 11 thus structured, the contact between the glass material 106

and the mount 101 can be prevented in the same manner as in Embodiment 10, and even when the stem body 113 and the mount 101 are joined to each other with solder or another material, the soldering material is prevented from adhering onto the glass material 106.

Embodiment 12

As shown in Fig. 19A, in the optical semiconductor device of Embodiment 12, the inner edge part of the mount 501 that faces the glass material 106 is made the round-edged circumference face 501c.

The radius of the round-edged circumference face 501c is set so that the glass material 106 and the mount 501 can be out of contact with each other by considering the installing position of the mount 501 and the spacing between the lead terminal for signal supply 112 and the circumference face 501a facing it.

In the optical semiconductor device of Embodiment 12 thus structured, the contact between the glass material 106 and the mount 501 can be prevented, and even when the stem body 113 and the mount 501 are joined to each other with solder or another material, the soldering material is prevented from adhering onto the glass material 106.

In the aforementioned embodiment 6 to 12, the mounts 61, 101, 201m, 301, and 501 are made of a metal such as

iron, iron alloy, copper, or copper alloy or of a dielectric member having a metalized surface. The circumference faces 61a, 101a, and 201b, and the flat surface 201a compose an earth conductor surrounding (or
5 facing) the lead terminal for signal supply 112.

Variation examples

Although in Embodiments 6 to 12 there is one lead terminal for signal supply 112, the present invention is
10 not restricted to this case. When more than one lead terminal for signal supply is used, the structure described in Embodiments 6 to 12 can be applied to each of the lead terminals for signal supply 112.

In Figs 21A and 21B, in the case that two lead
15 terminals for signal supply 112a and 112b are provided to differentially operate the semiconductor laser 103, the structure described in Embodiment 6 can be applied to each of the lead terminals for signal supply 112a and 112b.